SUSTAINABLE AGRICULTURE RESEARCH AT BARC

A Proposal Developed by The Task Force on Sustainable Agriculture Research at Beltsville

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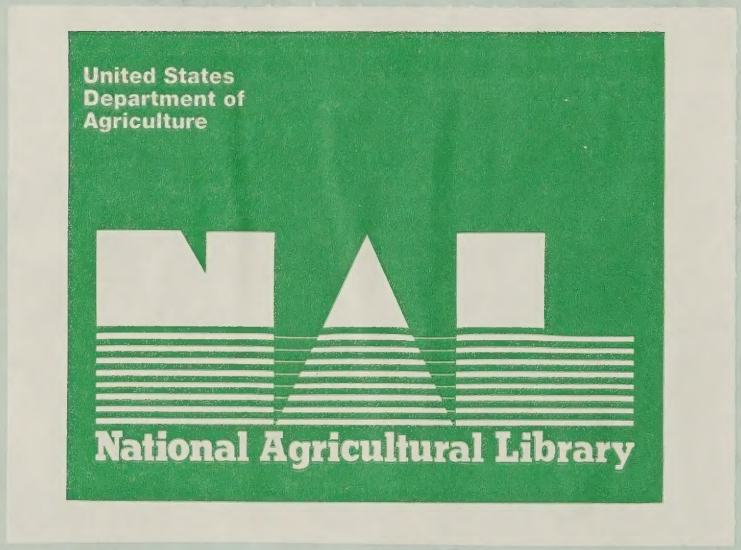
Agricultural Research Service

United States Department of Agriculture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EXECUTIVE SUMMARY

Sustainable agriculture is an envisioned system that, for the foreseeable future, will be productive, competitive, and profitable in producing and distributing food and fiber. Additionally, it must conserve natural resources, protect the environment, and promote public health.

A Task Force was appointed and charged with the responsibility of investigating opportunities for BARC to become more involved in research on sustainable agriculture. The Task Force concluded that BARC already has considerable research involvement in this area, but that additional opportunities exist.

Research on sustainable agriculture requires a holistic approach with scientists from multiple disciplines examining problems and potential solutions from many points of view. BARC has the necessary mix of scientist to form teams and undertake projects that require multidisciplinary research in essentially every area related to sustainable agriculture. In addition to the strength of its scientists, BARC has the necessary resources of land, facilities and equipment. BARC's location in an urban area is an asset, because a system of sustainable agriculture must be able to operate in proximity to centers of population and will probably utilize waste materials generated by them.

Because of its national and international reputation as a center of excellence, and because of its proximity to the capital, BARC should be a location where the principles of sustainable agriculture are demonstrated. A demonstration site could incorporate both newly established technology and ongoing research. It would serve the purposes of technology transfer as well as education of the general public.

The Task Force proposes the following broad programs in sustainable agriculture for BARC. Under these broad areas, the Task Force developed 27 specific proposals, which are presented in the Appendix.

- Managing water use and quality
- Utilizing waste products to enhance soil quality
- Improved cultivars, crop production models, crop quality and acceptability
- Improvements in pest control practices
- Improvements in animal systems
- Economic evaluation of sustainable agricultural technologies

TASK FORCE ON SUSTAINABLE AGRICULTURE

RESEARCH AT BARC

Don Bills - Chairman
Mike Faust - Vice-Chairman

SUBGROUPS OF THE TASK FORCE

1. Soil/Air/Water/Climate

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2. Cultural Practices/Pest Control

   George Papavizas - Leader

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3. Genetics/Biotechnology/Consumer Needs

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INTRODUCTION

About 10,000 years ago, man began to cultivate plants and keep animals. With time, this system for obtaining food essentially replaced the earlier system of hunting and gathering. We call the new system agriculture, and occasionally we need to remind ourselves that it is completely artificial and has never been in harmony with nature. Agriculture is, rather, a constant struggle against natural forces--pests, diseases, weeds, and weather--that threaten to deprive us of our food supply. By its very nature, the practice of agriculture disrupts the natural order of things and changes the environment. We can choose options that will affect the type and extent of the changes, but we can not return to the primeval environment without giving up all forms of agriculture and many other things that society cherishes.

The success of agriculture is remarkable. As hunters and gatherers, the number of people on earth never exceeded about 10 million, while agriculture supports a population of nearly 6 billion, a 600-fold increase. Before the 17th century, the stable population of Native Americans was about 1 million, but the same land today supports over 250 million and provides over $35 billion in agricultutal exports. Particularly in the 20th century, increasing population and economic incentives drove the expansion of agriculture in the U. S. and caused the adoption of some practices that now must be questioned. While it is clear that changes are needed, it also is clear that we can not abruptly shift into a lower gear that would cause starvation and economic collapse. Change must be based on sound research and economic considerations.

Sustainable agriculture is an envisioned system that, for the forseeable future, will be productive, competitive, and profitable in producing and distributing food and fiber. Additionally, it must conserve natural resources, protect the environment, and promote public health. The restrictive and subjective boundaries of organic farming, low input agriculture, and alternative agriculture are based somewhat on emotional appeal. Many of their premises are untested. A system of sustainable agriculture, on the other hand, must be based on sound research and demonstrated practical application, because economy and productivity must be considered. In the end, many of the concepts of low input agriculture and alternative agriculture will be adopted in a sustainable agricultural system. But, contrary to the philosophy of organic farming, chemicals and chemical fertilizers can be expected to play a role in sustainable agriculture when their use is economically sound and their effects on human health and the environment are neutral or beneficial.

THE NEED FOR RESEARCH

An early sign that agricultural practices can cause long-lasting damage appeared in the late 1950's when orchards that had been sprayed with lead arsenate for 25 years were replanted. Sufficient arsenate had accumulated in the soil to kill the young replants. Through

similar observations in the 1960's, we became aware that certain chemicals for pest control were becoming dispersed in soil, water, and the biosphere and were causing undesirable side effects. Agricultural practices for controlling pests must be integrated and compatible with the environment, but we lack alternate methods that will allow continued productivity and profit.

Another aspect of sustainability is the developing scarcity of materials needed for agriculture. A very important one of these is water. To sustain agricultural production, we will need plants that produce full crops with less water. Petroleum for nitrogen fixation and farm operations is increasingly expensive with no practical alternate energy source apparent. Systems that reduce the need for petroleum and other energy sources are needed. Agricultural practices must conserve non-renewable resources.

We need to enhance and expand soil resources. This concept goes beyond "soil conservation." Certain waste products may be well-suited for this purpose. In addition to benefitting agriculture, this approach could eliminate the problem of disposing of certain wastes. Agricultural practices should improve, not deplete, soil resources.

The reduction of pre- and postharvest losses from all causes is very important in a sustainable system. We can not afford to continue overproducing some horticultural crops, for example, by 30% to allow for the difference in demand versus the amount of unspoiled crop that can be delivered to the consumer.

Sustainable agriculture will depend upon increased knowledge and better management skills. Farmers will need to choose the best option for a given situation, and the option will often be a combination of approaches. Computer models and decision-making software packages need to be developed as systems of sustainable agriculture emerge.

In all movements toward a sustainable system, the economics of production, the safety and quality of the final product, and the consumer demand for the product will be the ruling factors.

Much of the past research that we have thought of as addressing "conventional" agriculture has achieved goals that exactly fit the needs of a sustainable system. Much of the current work at Beltsville and elsewhere in ARS addresses other needs of sustainable agriculture, although we have not yet attached that label to it. The need for additional research is evident.

ROLE OF BELTSVILLE IN RESEARCH ON SUSTAINABLE AGRICULTURE

Research on sustainable agriculture requires a holistic approach with scientists from multiple disciplines examining problems and potential solutions from many points of view. Existing agricultural technologies were often developed by individuals to solve specific

problems without giving adequate consideration to side effects and undesirable consequences. The very effectiveness of the methods that were developed often caused imbalances in the ecosystem. Future technologies must be developed by teams to avoid the one-dimensional approach. Beltsville has the necessary mix of scientists to form teams and undertake projects that require multidisciplinary research in essentially every area related to sustainable agriculture.

In addition to the multidisciplinary strength of our scientists, Beltsville is located in a relatively warm climate where plants require large quantities of water, thus making any decrease in water requirements easily perceived.

Beltsville soils are relatively heavy, nonporous, and difficult for roots to penetrate, thus making improvements in soil quality easily measured. Some potential soil amendments are readily available locally--paper wastes are abundant in the urban area, and nearby power plants can supply waste gypsum.

There is one consideration that transcends just the conduct of research. Because of its national and international reputation as a leader in agricultural research, and because of its proximity to the capital, Beltsville is an ideal location for a demonstration site for sustainable agriculture practices. The demonstration site would incorporate both newly-established technology and ongoing research. It would serve the purpose of transferring technology and generally educating the public. For optimum effectiveness, the site should be consolidated at one location at Beltsville rather than spread out over the 7,000 acre center.

We have identified a number of researchable problems related to sustainable agriculture that the Beltsville Area could address in an excellent manner. These are grouped under program headings and presented in a summarized form on the following pages and in detail in the Appendix.

PROPOSED SUSTAINABLE AGRICULTURE PROGRAMS FOR BARC

Managing water use and quality:

Improvement of soil permeability would allow roots to penetrate more deeply and obtain water more effectively. Development of plants that produce full crops with less water would decrease the need for irrigation with scarce water. Reduction of leaching of pesticides and fertilizer is needed, and modified practices of application and soil amelioration should be sought. Expansion of aquaculture requires attention to its influence on water quality.

To grow plants with less water is imperative in populated areas where people compete with plants and animals for limited quantities of water. The entire east coast can be included in this category. Growing plants with less water is even more important in warmer regions where plants require more water for evaporation. In general,

when the temperature increases from 20 to 30 degrees C, water use doubles. Irrigation is only a partial solution for providing the necessary amount of water to grow a full crop. In areas, such as the east coast, where rainfall is close to 1000 mm (40"), if losses through evaporation or downward movement in the soil could be prevented, the natural rainfall would be sufficient to grow most crops.

Methods to be investigated for their ability to increase rooting depth include deep liming (solid or slurry form), vertical mulching, surface or subsurface addition of gypsum, and the incorporation of green manure crops. In many cases, acid subsoils limit root penetration because such soils are high in aluminum, which is toxic to most plant roots. Genotypes that are aluminum tolerant could penetrate subsoils deeper than their non-tolerant counterparts and have access to a larger amount of water.

Because lawns typically are established on soils that limit root penetration, they require wasteful irrigation. At the same time, rainwater can not penetrate the heavy soil under the turf, and this increases the runoff problem. Runoff causes contamination of groundwater, streams and lakes with pesticides and fertilizer components. Methods are needed to improve root penetration of turf.

Another approach for limiting water use is to develop more efficient plants that require less water. We know that various plants require different amounts of water to produce a full crop. For example, most crops transpire 500 or more kg of water for each kg of carbon dioxide fixed, but apples require only 120 kg of water for each kg of carbon dioxide fixed. Species and cultivars need to be examined to discover the extent that water use can be influenced while maintaining productivity.

Specific proposals in this area include:

Proposal No.	Title
1	Increasing plant rooting depth.
2	Aluminum tolerant plant genotypes for reduction of drought losses.
3	Management of turfgrass to reduce inputs and recycle clippings and wastes.
4	Minimizing the use of water by plants.
5	Reducing groundwater pollution with sustainable agriculture methods.
6	Economic analysis of intensive water recycling in aquaculture systems.

Utilizing waste products to enhance soil quality:

Paper and gypsiferous wastes have great potential value to agriculture. Presently both materials are buried in landfills, causing ever increasing demands for landfills and persisting unchanged in the anaerobic environments of landfills for long periods. In

contrast, if they could be used in agriculture, gypsum could influence water penetration into soil and increase rooting depth, and paper mixed into the upper layer could decompose and increase the organic component of soil. There are reports that fusarium wilt can be controlled by addition of paper to the soil. A gypsiferous compound, FBM (fluidized bed material from coal burning) was reported to create a thin, hardened layer on the surface of the soil that prevented weed growth. This layer could be easily plowed under at the end of the season and become a soil amendment in the following year. We envision the development of methods that use a combination of ground paper and gypsiferous wastes as ground cover in the first year and soil amendment in the second year. If combined with the raised-bed method, it could minimize evaporation from the soil surface, now done by plastic, prevent weed growth, and add to soil organic material and soil structure in the second year. This possibility is especially important for vegetable and fruit crops such as strawberries.

Another possibility for utilizing waste products is as substrates in solid fermentations to grow microbial pest control agents (MPCAs) for biological control of soilborne plant pathogens and nematodes. Waste products also might be added directly to soils to supress soilborne plant pathogens and nematodes. There are agricultural byproducts, such as peanut hull meal, ground corn cobs, and whey; municipal wastes, such as composted sludge; and industrial wastes, such as brewing industry wastes, sawdust, bagasse and other wastes high in organic matter. Such wastes could be used in solid fermentation to produce sufficient biomass of Gliocladium, Trichoderma, and Talaromyces to supress soilborne plant pathogens Fusarium, Rhizoctonia and Sclerotium, all important pathogens of vegetables and ornamental plants. If added to the soil directly, these wastes might shift soil microcommunities to favor the production of biocontrol agents. However no such studies have been performed so far, and new research could significantly add to the scant present knowledge in this field.

Even though we have considerable experience in composting sewage sludge, research on composting other wastes and the use of composted material is still needed. Composting poultry and other manures is accompanied by an unacceptable odor and fly breeding problems. Manure could be composted as a solid in pits or as a liquid in lagoons under plastic covered structures where air drawn over absorbents could minimize odor problems during fermentation. Insect management systems could control fly populations. Methods of composting and utilization of composted manures should be examined.

One of the best ways to prevent losses of inorganic fertilizers and pesticides into ground water is to increase soil organic material which prevents leaching. The effectiveness of added biodegradable or composted materials and the rate of applications to prevent nitrogen and pesticide leaching is unknown.

Specific proposals in this area include:

Proposal no.	Title
7	Enhancing soil quality with a combination of gypsiferous wastes and paper waste.
8	Waste utilization to enhance biocontrol of plant diseases and nematodes and increase crop productivity and sustainability.
9	Develop animal and poultry manure management systems.

Improved cultivars, crop production models, and crop quality and acceptability:

In the past, we increased crop productivity by developing highly productive cultivars that required high levels of fertilization, pest protection, and water. The quality of such cultivars is high and their productivity is excellent, but their role in a sustainable system is questionable. We need cultivars that are equally excellent and productive with less input.

For developing such cultivars, we need to draw on existing or develop new germplasm that has the needed characteristics. Resistance to insects, resistance to toxic elements, such as Al, Se, and Mn, are important, and plants that can take up water from relatively dry soils are of interest.

Modeling that reliably pinpoints where input can be reduced will be important to a system of sustainable agriculture. Models that predict the effect and magnitude of reducing a given input on final productivity are necessary to the decision making process. Models developed through this research would aid growers in choosing cultivars, applying fertilizers, pesticides and irrigation.

Products grown with new methods are likely to have new properties. Quality, nutritional value, safety, and consumer acceptability may all change. Monitoring changes in products produced with technology developed for sustainable agriculture will be important.

Specific proposals in this area include:

Proposal no.	Title
10	New fruit and vegetable cultivars adapted to low input farming.
11	Collection, evaluation, preservation and introduction of wild germplasm.
12	Sustainable and economic production of fruits and vegetables through crop modeling.
13	Monitoring changes in safety, nutrient composition, quality, and consumer acceptance of foods resulting from sustainable agriculture practices.
14	The development of process level models describing sustainable agricultural practices, and their integration into crop simulators

Improvements in pest control practices:

Integrated pest management has been practiced in terms of the biology of a given pest. The life cycles of certain pests were examined and the point at which the life cycles could be interrupted by biologically acceptable methods were identified. Occasionally, other practices were modified to accommodate a new pest control technique. Hence, the name integrated pest management has been used. However, there is a need to establish long-term, multi-disciplinary investigations of pest management technologies in field crops grown under various row spacing, cover crops, crop rotation, living and killed mulches, environmentally and socially acceptable municipal, industrial and agricultural wastes plus selected tillage practices.

Integration of microbial agents and insect parasites for reducing pesticide residues in vegetables is needed. Improved strains of Bacillus thuringiensis and nuclear polyhedrosis viruses; enhancement of predatation with behavioral chemicals; and importation of more effective parasites are the most likely approaches that need to be investigated.

Use of beneficial fungi compatible with reduced amounts of pesticides is essential to achieve the full potential of integrated control of plant diseases. Research is needed on soilborne fungal propagules that have been attenuated by solarization or sublethal fumigation to make them more sensitive to biocontrol agents. We also need to identify and characertize naturally-occurring biocontrol systems (supressive soils) and from these isolate and identify microbes capable of disease supression.

Recently it was discovered that roots of various tree crops were colonized by VAM under grass-covered areas, whereas no colonization occurred in clean cultivation. Exudates of grass roots may have played a role in root colonization of the trees. It appears that plant exudates may be controlling factors in determining microbial populations. Elucidation of these factors may allow us to manipulate microbial population in the rhizosphere.

Specific proposals in this area include:

Proposal no.	Title
15	Integrated pest management technologies for sustainable agriculture, efficacy and environmental impact, and comparison with conventional systems.
16	Microbial agents, entomophagous arthropods, and behavior-modifying chemicals to control insects, reduce pesticides in foods, and enhance sustainable agriculture.
17	Achieve the full potential of integrated control of plant diseases as a major component of sustainable agriculture.

18 Development of microbial gene probes for characterizing beneficial plant/microbe/soil interactions in sustainable agriculture.

19 Enhance agricultural sustainability and reduce losses from soilborne plant pathogens and nematodes with soil management practices.

Improvements in animal systems:

A system of sustainable agricultural must be as economical as possible. Presently, animals produce considerable fat containing an energy calue of 9 Kcal per gram which requires the expenditure of many times that amount of energy to produce. Consequently, the production of animal fat requires large expenditures of agronomic products, yet produces little or no value nutritionally or monetarly. Animals that produce less fat are needed.

Ruminant animals utilize forage for approximately 70 to 90% of the total dry matter they consume. The most economical means of providing this forage is through grazing. Small-scale studies have shown that grazing is a practical alternative in the mid-Atlantic states. The system should be extended and the total aspect of grazing explored.

The largest single cost in poultry production is for feed. Preliminary research has shown that egg production can be maintained on a ration of alfalfa, corn, soybean silage. Such feeding saves part of the cost needed for drying of feed grains. The proposed research will optimize the composition and preparation of silage, particularly for growing birds and breeder chickens which have not been studied yet.

Artificial insemination (AI) is practiced widely in the turkey industry. Presently semen can be stored for hours without a drop in fertility. This allows separation of male and female breeders which in turn augments fertility because of the improved management of male birds and necessitates fewer males for a given number of females. A further improvement in AI technology that would allow storage of semen to 48 hrs has the potential to develop new market for semen (sale of semen) and to decrease the male to female ratio even further.

Reducing both the mortality of chickens caused by enteric pathogens and the use of the preventive and therapeutic drugs to cure these diseases is desirable. Presently genetic markers are available to permit identification of individuals with enhanced natural immunity to pathogens. It is desirable that the role of host genes in chickens are identified in disease succeptibility to enteric pathogens including salmonellosis and coccidiosis. Such programs would improve resistance to such diseases.

Colostrum from dairy cows can be used for prevention or treatment of a diarrheal disease, cryptosporidiosis. The concept could be further extended to other diseases such as intestinal protozoa, bovine, ovine and porcine coccidiosis.

To improve production efficiency of ruminant food animals through the reduction of helminth parasite burdens by natural mechanisms is important. The hystocompatibility in ruminant live stock that affect resistance/succeptibility to gastrointestinal helminth parasites should be identified and the mechanism of tolerance and the role of host hormonal regulation of immunity to these diseases elucidated.

Specific proposals in this area include:

Proposal no.	Title
20	Low-input grazing system for cattle and sheep production.
21	Silage-based low-input feeding system for poultry production.
22	Improve artificial insemination technology for increased efficiency in turkey breeding.
23	Genetic enhancement of disease resistance to enteric pathogens in poultry.
24	Use of bovine colostrum to prevent and treat disease in companion animals, livestock and humans infected with protozoan parasites
25	Immunology and identification of genes and gene products controlling resistance to helminths of ruminants.
26	Production of bispecific antibodies to combat mastitis pathogens in lieu of antibiotics.
27	Efficacy of bovine somatrotrophin for increasing sustainability of milk production.

Economic evaluation of sustainable agricultural technologies:

Physical and biological scientists will develop many new components of sustainable agricultural technologies. Data are needed to integrate findings from science with financial analysis.

Specific proposals in this area include:

Proposal no.	Title
6	Economic analysis of intensive water recycle acquaculture systems. (Also listed under Water Quality.)
12	Sustainable and economic production of fruits and vegetables through crop modeling. (Also listed under Improved Cultivars.)

APPENDIX

Title: Increasing Plant Rooting Depth

Objectives: 1) Develop methods for ameliorating root-limiting factors in subsoils. 2) Identify or develop plant genotypes with ability to root deeper.

Rationale and Relationship to Sustainable Agriculture: A major cause of shallow rooting and drought losses is Al toxicity in strongly acidic (pH 5.0, or below) subsoils. Mixing lime with surface soils does not effectively neutralize Al in subsoils. Preliminary evidence indicates that at least in coarse textured soils, surface application of gypsum products can increase the downward movement of Ca, decrease the Al saturation of subsoils and increase rooting depth These products may also increase soil particle aggregation, increase rainfall penetration and decrease soil erosion. Deeper rooting plant genotypes should improve drought tolerance. Soil modification techniques and the use of stress tolerant plant genotypes could increase crop production on large acreages (estimated 300 million acres in the Eastern U.S. alone) and contribute to sustainable agriculture. The increased rooting depth resulting from these two approaches could improve the physical and chemical properties of subsoils and reduce the probability of groundwater pollution.

Approach: 1) Soil amelioration methods to be tried include subsoiling, deep liming (solid or slurry form), vertical mulching, surface or deeper incorporation of gypsum or fluidized bed slag, incorporation of green manure crops and deep placement of fertilizers. For these studies, standard crop cultivars would be used. 2) Plant genotypes known to differ in abilities to root in acid subsoils will be grown in simulated soil profiles or on field sites having subsoils that limit root penetration. In both soil modification and plant genotype experiments, plants will be characterized with respect to rooting depth, resistance to drought, depletion of subsoil water, water use efficiency and yield. The effects of experimental treatments will be measured with physiological and biochemical techniques.

Participants:

1) Climate Stress Laboratory, NRI
   - C. D. Foy
   - D. T. Krizek
   - E. L. Vigil
2) Environmental Chemistry Laboratory, NRI
   - Jack Meisenger
3) Soil Microbial Systems Laboratory, NRI
   - Sharon Hornick
   - Pat Milner
4) Soybean and Alfalfa Research Laboratory
   - Austin Campbell

Additional Funding Use:
Two new SY positions, technical support, and costs of field labor

Proposal Developed By: Charles Foy

Title: Aluminum-Tolerant Plant Genotypes for Reduction of Drought Losses

Objectives: Test the hypothesis that Al-tolerant plants will penetrate acid subsoils deeper, use subsoil water more effectively, and resist drought better than Al-sensitive genotypes of the same species.

Rationale and Relationship to Sustainable Agriculture: A major cause of drought losses is shallow rooting of plants associated with Al toxicity in strongly acidic subsoils (below pH 5.0). An estimated 83 million acres in the Northeastern U.S. and 215 million acres in the Southeastern U.S. are sufficiently acid and infertile to reduce plant growth through the interaction of Al with mineral element deficiency or unavailability and drought. In most soils, lime applied to the plow layer does not effectively neutralize subsoil Al, and mixing lime with the subsoil is generally not economically feasible. We postulate that Al-tolerant, deeper-rooted plants will offer some protection against drought, increase the use of subsoil water and nutrients and reduce the need for subsoil liming and for irrigation. Deeper rooted plants could absorb excess nitrate and decrease groundwater pollution.

Approach: Al-tolerant and sensitive genotypes of selected species will be subjected to drought vs. non-drought conditions in the presence or absence of Al. Plants will be compared in simulated soil profiles, in solutions containing PEG 8000 and in field plots having acid, Al-toxic subsoil layers. Measurements made will include root morphology (root length, density, dry weight), shoot morphology (leaf area, leaf dry weight, stomate density, growth analysis, trichome density, lateral bud growth) and shoot and root physiology (water extraction from subsoils, resistance to drought symptoms, water use efficiency, mineral elements fluxes in roots and distribution in plants, photosynthetic rate, stomatal conductance, transpiration rate, leaf water potential, osmotic potential, turgor potential and soil matric potential.) Ultra-structure will be examined by EM and NMR imagery. Effects of Al and drought on chemical composition will be determined by P31 NMR, leaf temperature by infrared thermometry and Photosystem II activity by chlorophyll fluorescence.

Participants:

1) Climate Stress Laboratory, NRI
   C. D. Foy
   D. T. Krizek
   E. L. Vigil

Additional Funding Use:

Postdoctoral position and costs of technical support and field labor

Proposal Developed By: Charles Foy

Title: Management of Turfgrass to Reduce Inputs and Recycle Clippings and Wastes

Objectives: Test the response of new and existing turfgrass varieties to reduced fertilizer, pesticide and water inputs in conjunction with various mowing frequencies to manage and recycle grass clippings. Evaluate turfgrass response which grass clippings are returned to the soil profile, or are collected and composted with other common urban waste products and applied, as with municipal sewage sludge, as fertilizers.

Rationale and Relation to Sustainable Agriculture: Grass clippings comprise a major portion of the urban waste products that are placed in landfills. If clippings were recycled by leaving them on the turf or by composting them, nutrients would be recycled and landfill space would not be used needlessly. Similarly, composted sewage sludge can serve as a valuable fertilizer and soil conditioner and provide an alternate media to topsoil for growing turf for sod production, thus reducing the loss of irreplaceable topsoil during sod harvesting.

Approach: New dwarf turfgrass varieties and low maintenance turfgrass species, such as zoysia and buffalograss, and cool season turfgrass cultivars with endophyte-enhanced insect resistance will be selected and evaluated with respect to their management, clipping production and recycling potential. The use of incorporated or surface applied sewage sludge for sod production, maintenance and minimization of topsoil loss during sod harvesting will be evaluated. Grasses will be grown in field trials under various application rates of pesticides, fertilizer, sludge and irrigation and varying moving frequency Measurements will be made to determine incidence of disease, insects, and other stresses (water, temperature, etc.), the rate of growth, clipping decomposition or thatch build-up, microbial populations, weed competition, changes in soil organic matter, pH, nutrient content and pesticide persistence. Small-scale or "backyard" composting will be conducted to evaluate the suitability of recycling bagged grass clippings with common household waste products such as newspaper, leaves, hedge trimmings, shrub prunings, coffee grounds, eggshells, vegetable and fruit parings, etc. Fertilizer value of compost and pesticide degradation and persistence will be measured.

Participants:

1) National Turfgrass Evaluation Program
   K. Morris, Director
2) Soil Microbial Systems Laboratory, NRI
   S. Hornick
   L. Sikora
3) Pesticide Degradation Laboratory, NRI
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4) Weed Science Laboratory, PSI
   B. Coffman
   J. Teasdale
5) Soybean and Alfalfa Research Laboratory, PSI
   N. O'Neill
6) Biocontrol of Plant Disease Laboratory, PSI
   G. Papavizas
7) Environmental Chemistry Laboratory, NRI
   J. Meisinger

Additional Funding Use:

One full-time SY, technical support, labor costs, and a cooperative agreement with the Department of Entomology, University of Maryland.

Proposal Developed By: Sharon Hornick

Title: Minimizing the Use of Water by Plants

Objectives: Examine species and cultivars to determine the extent that water use can be reduced, while maintaining productivity, and establish agronomic technologies that minimize water use.

Rationale and Relation to Sustainable Agriculture: To sustain agricultural production, the use of water must be minimized. Drought stress has been studied and the number of stress days many species can withstand is known. However, drought resistance is an emergency response of plants. Crops require differing amounts of water under non-drought conditions. For example, most crops use 500 kg or more water for each kg of dry weight produced, but apples require only 120 kg of water. Furthermore, there are differences between apple cultivars and growing conditions that influence water use by 20 percent for producing a full crop. Traditionally, preserving soil water, increasing penetration of water into the root zone, and developing irrigation technology have been the research lines followed to conserve water. The plant, which expends most of the water, has not been considered. Technology that limits water use by the plant is needed.

Approach: Basic plant mechanisms that control water expenditure will be sought and described. Plants evaporate water to cool the leaves and fruit. More than 2/3 of the incoming energy is used for that purpose. If water use is decreased, the energy not used for evaporation of water increases leaf and fruit temperature. This can cause serious consequences. Thermal resistance of plants will be studied and the mechanism for high temperature tolerance elucidated.

Participants:

1) Vegetable Laboratory, PSI
   S. Sinden
2) Climate Stress Laboratory, NRI
   C. Foy
3) Fruit Laboratory, PSI
   M. Faust

Additional Funding Use:

Two postdoctoral positions and technical support

Proposal Developed By: M. Faust

Title: Reducing Groundwater Pollution with Sustainable Agriculture Methods

Objectives: To research and develop techniques for reducing losses of nitrogen and pesticides into groundwater and to integrate these techniques into practical long-term farm management systems.

Rationale and Relation to Sustainable Agriculture: Preserving groundwater quality goes hand-in-hand with sustainable agriculture because the rural population is almost completely dependent on groundwater for their domestic and livestock water supplies. The impact of a given N and pesticide management system on groundwater quality is often felt first by the individual farmer because he is the first to consume the water percolating through his fields. Therefore, agricultural management techniques should be geared toward recharging good quality water in order to maintain high quality rural water supplies and thereby ensure a sustainable agriculture enterprise.

Approach: Research will be conducted with lysimeters, field plots, and transport models to develop and evaluate techniques to reduce the leeching of N and pesticides into groundwater. Nitrogen management techniques studied will include methods to assess the soils ability to supply N (e.g., refinement of the pre-sidedress nitrate test), N placement in conservation tillage systems (injection of N below soil surface), cover crops to conserve residual N, and deep-rooted crops to scavenge N. Pesticide management techniques will include expert systems to select pesticides with reduced mobilities for a given site, safer pesticide mixing/rinsing areas, encapsulation of pesticides for slow release, and development of low input pesticide practices to be used with IPM or traditional cultivation systems. Non-agricultural areas, such as riparian zone and buffer strips, should also be studied to determine their ability to improve water quality. The management of these areas should also be studied; for example: species selection, harvesting frequency, and the size of area to achieve the desired improvement in water quality.

Participants:

1) Environmental Chemistry Laboratory, NRI
   Jack Meisinger
2) Pesticide Degradation Laboratory, NRI
   George Fries
3) Systems Research Laboratory, NRI
   Basil Acock
4) Hydrology Laboratory, NRI

Additional Funding Use:

Three new SY positions and technical support

Proposal Developed By: Jack Meisinger

Title: Economic Analysis of Intensive Water Recycling in Aquaculture Systems

Objectives: Estimate annual cost per pound of fish harvested and analyze cash flow of the intensive water recycle aquaculture system currently being developed at the Spring and Ground Water Resources Institute.

Rationale and Relation to Sustainable Agriculture: Aquaculture has a potential for augmenting existing commercial and recreational fisheries and providing a new and potentially profitable enterprise for small and mid-size farms. In 1988, the ARS funded a 5-year, $3.8 million project to the Spring and Groundwater Resources Institute of the Conservation Fund to develop environmentally sustainable aquaculture and plant culture systems. The Institute is developing a combination of aquaculture and plant culture systems which is capable of reusing greater than 95 percent of the water used. The used water from aquaculture will be used for hydroponics, drip irrigation and similar plant growth methods. The water will then pass through a biological filter before returning to the fish tanks Thus, this system conserves scarce water resources and will not pollute the environment. It also offers opportunities for producing high-value products and unique crops grown out of season.

However, in order for the system to be sustainable, the system must be profitable in order to provide farmers incentive to adopt it. Otherwise, no matter how good the system is, farmers will not adopt the system and the system is useless. The proposed project will evaluate the profitability of the system, analyze cash flow, and recommend the optimum size of operation under different marketing strategies.

Approach: Economic-engineering approach will be used to estimate investment costs, annual ownership costs, annual operation costs, and then calculate annual cost per pound of fish harvested for different sizes of operation under various marketing strategies.

Participants:

1) Systems Research Laboratory, NRI
   Yao-chi Lu
2) Spring and Groundwater Resources Institute
   Shepherdstown, West Virginia
   Robert E. Putz

Additional Funding Use:

One scientist and a computer assistant

Proposal Developed By: Yao-chi Lu

Title: Enhancing Soil Quality with a Combination of Gypsiferous Wastes and Paper Wastes

Objectives: Develop innovative procedures for the environmentally-sound utilization of gypsiferous wastes and paper wastes to increase plant root penetration for greater water and nutrient efficiency.

Relationship to Sustainable Agriculture: Environmentally-sound strategies for utilizing large quantities of waste products are needed. Utilization of waste products that enhance the soil should receive a high priority. Power plant waste products not only contain agriculturally needed nutrients but also compounds, such as gypsum, that can increase plant root penetration and result in improved water and nutrient utilization. Incorporation of biodegradable products reduces the need for inorganic inputs. More efficient water usage decreases both the actual amount of water needed and the potential for nutrient and pesticide leaching. Paper wastes also increase the soil organic matter content aiding in higher soil microorganism levels and better tilth. The unique cementing properties of power plant wastes would allow reduction of herbicide use by reducing weed seed germination. The above conclusions are based on preliminary work with gypsiferous wastes in the Fruit Lab. However, much research is needed to develop detailed recommendations for using combinations of a variety of waste products to improve soils.

Approach: Liquid or solid gypsiferous wastes from power plants will be mixed with ground newspaper, creating a novel mulch material. This mulch will be applied on mounded soil rows for a variety of small fruits including strawberries and fruit trees. This will allow for both short and long term studies on the effects of the mulch on root penetration, enrichment of soil materials and water and nutrient usage. Strawberries are planted on a 3 year rotation (short term) and tree fruits remain in place for a minimum of 10 years.

Mixing the power plant wastes with waste paper will result in a cementing effect which will reduce the problem of holding the paper in place. Plowing the mulch at the end of a rotation will add biodegradable material (paper) into the upper soil layer which will enhance soil organic matter.

Participants:

1) Fruit Laboratory, PSI
   R. F. Korcak
   M. Faust
2) Soil Microbial Systems Laboratory, NRI
   S. Hornick
3) Climate Stress Laboratory, NRI
   C. D. Foy

Additional Funding Use:

Two new SY positions and costs of field labor

Proposal Developed By: M. Faust

Title: Waste Utilization to Enhance Biocontrol of Plant Diseases and Nematodes and Increase Crop Productivity and Sustainability

Objectives: 1) To utilize agricultural and industrial wastes as substrates in a solid fermentation system to grow microbial pest control agents (MPCAs) for biocontrol of soilborne plant pathogens and nematodes; 2) to add municipal, agricultural and industrial wastes directly to soil to suppress soilborne plant pathogens and nematodes, improve tilth, soil separation, management of soil microbial populations, and increase crop growth and productivity.

Rationale and Relation to Sustainable Agriculture: The proposed research will enhance agricultural sustainability in at least three ways: Eliminate certain wastes that otherwise require considerable expense for disposal; utilize waste products to promote environmentally compatible pest controls; and improve soil conditions and, indirectly, plant growth and productivity.

Approach: Previous research at Beltsville showed that certain agricultural, municipal or industrial wastes added to soil reduced the impact of certain soilborne plant diseases. Research also showed that certain wastes can be used to produce large amounts of fermentation products of MPCAs for biocontrol. The technological aspects of fermentations and the ecological interactions of microbials in soil and plant rhizosphere when organic wastes (with or without MPCAs) are added to soil are poorly understood. These deficiencies are clearly serious deterents to the advancement of biological control using wastes to propagate MPCAs. Inexpensive, readily available agricultural by-products (e.g., manures, peanut hull meal, milk whey, etc.), municipal wastes and industrial wastes (e.g., oil cakes, brewery industry by-products, sawdust, bagasse, etc.) high in organic matter will be used in experimental solid fermentation systems to produce sufficient biomass of MPCAs to be used in experiments to suppress selected soilborne plant pathogens on vegetables and ornamental plants. Wastes will also be added at various concentrations directly to soils infested with important pathogens or nematodes to determine their impact on losses caused by the pathogens. In addition to disease assessment and yields, basic ecological studies will be performed to determine whether organic matter added to soil together with MPCAs creates shifts in the micro-equilibrium in soil and rhizosphere to decrease the inoculum density of the pathogen in a sustainable agricultural system.

Participants:

1) Biocontrol of Plant Diseases Laboratory, PSI
   George C. Papavizas
2) Nematology Laboratory, PSI
   Robin N. Huettel
3) Soil Microbial Systems Laboratory, NRI
   Donald D. Kaufman

Additional Funding Use:

Three new SY positions

Proposal Developed By: George C. Papavizas

Title: Develop Animal and Poultry Manure Management Systems

Objectives: Establish new ways to use manure and animal bedding in crop or animal production systems, or as a source of energy that will reduce fertilizer or animal nutrient input costs and dispose of manure in ways that will not contaminate groundwater or produce undesirable odor or insect problems.

Rationale and Relation to Sustainable Agriculture: Animal and poultry manure and bedding is a valuable source of fertilizer and organic matter that could help reduce input costs for animal and crop producers. At the same time disposal or application of these by-products pose environmentally sensitive problems related to groundwater contamination, undesirable insect production, and offensive odors (especially when used near urban areas). New technology is needed to improve the efficiency of their use and to reduce environmental pollution resulting from application of manure to agricultural land. Such technology would aid in reducing the use of insecticides to control insects breeding in manure. Judicious use of insecticides would reduce environmental pollution, or concerns related to their use, and problems of insecticide resistance in insects, which reduces the effective life span of important chemicals.

Approach: Investigate ways to store and apply manure that minimize loss of nutrients during storage or application, and avoid the development of conditions that produce unacceptable odor or fly breeding problems. Manure will be stored and composted in novel ways. Further research into the use of manure as a source of methane, or as a feed for livestock or poultry will be conducted. The use of manure to raise fly pupae or flies as a feed for poultry and fish will be investigated. Insect management systems could be improved to implement the most efficient and effective chemical, mechanical and biological methods for suppression. Present research at Beltsville is directed to development of methods of fly control involving no insecticides or a reduced use of insecticides. This includes the use of traps to attract and kill flies, the role of fly pupal parasitoids to reduce fly populations, and determination of breeding sites and methods to reduce breeding.

Participants:

1) Livestock Insects Laboratory, LPSI
   R. W. Miller
   L. G. Pickens
   E. T. Schmidtmann

Additional Funding Use:

One new SY position and technical support

Proposal Developed By: R. W. Miller

Title: New Fruit and Vegetable Cultivars Adapted to Low-Input Farming

Objectives: Breed and genetically engineer major fruits and vegetables to provide growers with new cultivars that are better adapted to low input agricultural systems.

Rationale and Relation to Sustainable Agriculture: Fruit and vegetable production presently requires very high levels of pesticides, fertilizers, and water to obtain economic yields. Attempts by commercial growers and researchers to produce fruits or vegetables with low input, sustainable production practices generally meet with unacceptable yield and quality reductions. This is at least partially due to the fact that breeders selected most of our modern cultivars for maximum performance in plots that were maintained under high input, optimum growing conditions typical of most commercial operations--ample irrigation, heavy application of herbicides and pesticides, optimum or even supraoptimal fertilization, etc. Thus, these cultivars are frequently narrowly adapted to high input monoculture. By selecting plants grown under low input conditions, including such cultural practices as intercropping, IPM and biocontrol measures for pests, weeds and diseases, it will be possible to develop new cultivars that are much better adapted to low input farming. At BARC we have ongoing potato, tomato, and small fruit breeding and biotechnology programs. These programs, working in cooperation with scientists in other laboratories that are developing new biocontrol measures for pests, diseases and weeds, and new cultural practices to overcome heat and drought stress conditions, can test the idea of selection under low input conditions to develop cultivars better adapted to sustainable fruit and vegetable production.

Approach: 1) Establish field plots at BARC that will be maintained long-term with minimum inputs of synthetic pesticides, fertilizers, and herbicides and with sustainable cultural practices such as crop rotation, minimum till, and living mulch. 2) Select germplasm and genetically engineered plants for economic yield and quality in these new, low input field plots.

Participants:

1) Biocontrol of Plant Diseases Laboratory, PSI
   G. Papavizas
2) Fruit Laboratory, PSI
   M. Faust
3) Vegetable Laboratory, PSI
   S. Sinden
4) Insect Biocontrol Laboratory, PSI
   B. Schroeder
5) Weed Science, Laboratory, PSI
   J. Teasdale
6) Climate Stress Laboratory, NRI
   S. Britz

Additional Funding Use:

Research Horticulturist and technical support

Proposal Developed By: Stephen L. Sinden

SPECIFIC PROPOSAL NO. 11

Title: Collection, Evaluation, Preservation, and Introduction of Wild Germplasm

Objectives: To develop, through the use of wild germplasm, agricultural plants better adapted to a wider range of soil types, increased cold and heat tolerance and other climatic stresses.

Rationale and Relation to Sustainable Agriculture: Wild germplasm is a critical non-renewable resource that is rapidly declining, but can be exploited and preserved through exploration and culture. Crop improvement and even persistence is greatly dependent on natural genetic adaptability to pest resistance and environmental stresses. The discovery and preservation of potentially useful wild germplasm is essential to the present and future needs of agriculture. USDA has been active in plant exploration for about 100 years, but there is still a great deal of unexploited biodiversity. Now needs re occurring that were not previously considered, such as: resistance to new threatening insects, diseases, and other pests; improved tolerance to natural and man-induced toxic elements such as Al, Se, Hg, and Mn; natural chemical constituents such as low fats, specific sugars, and higher protein.

Approach: Increased activity is needed in plant exploration and cooperative evaluation and increased support is needed for germplasm repositories for seed and intact plants. While biodiversity is recognizable in a general sense, exploration is more effective when specific desirable characteristics are sought. Researchers with special needs will define characteristics that explorers need to search for.

Participants:

1) Climate Stress Lab, NRI
2) Germplasm Institute, PSI
3) U.S. National Arboretum
4) Labs working with specific crops

Additional Funding Use:

Support exploration, evaluation and maintenance of wild germplasm

Proposal Developed By: Gene Eisenbeiss

Title: Sustainable and Economic Production of Fruits and Vegetables Through Crop Modeling

Objectives: 1) Develop crop models for major fruits and vegetables that include all of the important factors influencing production costs, yield, and market quality. 2) Evaluate economic impact of reducing fertilizer, water, and pesticide inputs. 3) Develop expert systems for growers and extension personnel.

Rationale and Relation to Sustainable Agriculture: Good crops are available for many of the major field crops, but modeling for horticultural crops is only beginning. The models developed through this approach permit valid comparisons to be made among various cultural and pest control practices to determine their effects on yield, quality, and profit. These comparisons could be simple, such as no-till using herbicides vs. tractor cultivation, vs. living mulch for weed control, or more complex, such as comparing conventional growing systems with low input, more sustainable systems. The expert systems developed from the models would aid fruit and vegetable growers in making decisions about fertilizer rates and types and pesticide and irrigation applications, thus minimizing inputs of costly resources while still obtaining optimum economic yields. The result would be reduced use and cost of chemicals and water, leading to higher profits for growers and lower prices for consumers. There is marketing research, weed research, and systems research expertise as well as ample expertise in fruit and vegetable production at BARC for developing crop models and expert systems.

Approach: Collect data from field experiments designed specifically for developing models and expert systems for sustainable and economic production of major fruits and vegetables using lower inputs of chemicals and water. Measure the effects of reduction in fertilizer, pesticide and irrigation inputs, and replacement of certain pesticides by biocontrol measures for diseases, insects, and weeds on yield and quality. Record the costs related to labor, equipment, and damage from insects and diseases. Develop models and expert systems that include the major factors influencing production and quality to help growers in making decisions that will lead to more sustainable and profitable production.

Participants:

1) Vegetable Laboratory, PSI
   S. Sinden
2) Fruit Laboratory, PSI
   M. Faust
3) Weed Science Laboratory, PSI
   J. Teasdale
4) Systems Research Laboratory, NRI
   Y. C. Lu
5) Horticultural Crops Quality Laboratory, HCQL
   A. Watada

Additional Funding Use:
Research Horticulturist and Computer Programmer

Proposal Developed By: Stephen L. Sinden

Title: Monitoring Changes in Safety, Nutrient Composition, Quality and Consumer Acceptance of Foods Resulting From Sustainable Agricultural Practices

Objectives: Determine interactions of management practices that affect nutrient quality. Determine changes in nutrient composition and quality of new agricultural products resulting from sustainable agricultural practices; identify new and monitor known toxic components; and identify potential consumer concerns regarding selected products.

Rationale and Relationship to Sustainable Agriculture: Sustainable agricultural practices may produce increased levels of toxicants in food products or enhance or decrease nutrient usefulness. New products resulting from sustainable agriculture practice may meet with resistance from consumers. As new agricultural processes and products are developed, potential consumer concerns should be identified and adjustments made to the processes or products. In some cases, the appropriate response would be to influence consumer demand by changing consumer attitudes and knowledge through informational programs.

Approach: Conduct laboratory, growth room, and field studies to characterize the mechanisms by which fertilizers, pesticides, cultural management practices, crop residues, soil organic matter, cultivar and climatic factors affect the nutritional quality and subsequent bioavailbility of nutrients and microelements in crops.

Determine changes in the nutrient composition and toxic composition of food products that result from sustainable agricultural practices. Through surveys, focus groups, sensory panels and other measurement techniques, determine whether consumers have attitudes that may prevent the acceptance of new products. If so, identify which characteristics of the product create potential concerns.

Participants:

1) Nutrient Composition Laboratory, BHNRC
   G. R. Beecher
2) Family Economics Research Group, BHNRC
   Frankie Schwenk
3) Horticultural Crops Quality Laboratory, PQDI
   A. E. Watada
4) Meat Science Research Laboratory, PQDI
   A. E. Kotula
5) Soil-Microbial Systems Laboratory, NRI
   Sharon Hornick
   Rufus Chaney
6) Weed Science Laboratory, PSI
   Ben Coffman

Additional Funding Use:

Two new SY positions, four technical support personnel, two postdocs, cooperative agreements

Proposal Developed By: Frankie, Schwenk, Sharon Hornick, Ben Coffman

Title: The Development of Process Level Models Describing Sustainable Agricultural Practices, and Their Integration into Crop Simulators

Objectives: 1) Develop process level models that simulate various sustainable agricultural practices. 2) Integrate these models into simulators for the major crops. 3) Evaluate these sustainable agricultural practices for their impact on crop production and the environment. 4) Develop integrated crop simulation models for use as farm decision aids.

Rationale and Relation to Sustainable Agriculture: Crop simulators are executable computer programs that numerically describe the daily physical, physiological, and morphological effects of imposed variables on the crop. The imposed variables include natural, environmental and applied management inputs. The daily calculations continue until the end of the growing season, and a harvestable yield is predicted. Because of advancing computer technology, crop simulators are now practical tools for the farmer to use on the farm. Crop responses to particular treatments can be simulated and quantified to aid in daily management decisions.

Quantifiable information is available on various sustainable agricultural practices; however, no attempt has been made to predict how the various practices will interact. We propose to develop models using existing knowledge of various practices and integrate these models into crop simulation models.

The integrated crop simulation models will enable us to: 1) Study the overall cropping systems under sustainable agriculture, and assess the impacts of various practices; 2) Help scientists identify knowledge gaps in sustainable agriculture; 3) Develop a farm management tool for farmers to optimize various inputs; 4) Study the impact of sustainable agriculture on overall crop production, water quality, and other environmental variables.

Approach: Collect data on the effects of various sustainable agricultural practices and the processes involved. Use process level models to describe our best understanding or hypotheses about these processes. Incorporate these models into existing crop simulators and validate them. Run the crop simulators for the various plausible combinations of soil, weather and management operations to evaluate the impact of sustainable agricultural practices on crop yield and the environment. Prepare the integrated crop simulators for use on the farm.

Participants:

1) System Research Laboratory, NRI
   Basil Acock
2) University of Idaho
   Vangimalla R. Reddy
   Tony Trent

Additional Funding Use:

Two scientists and a computer programmer

Proposal Developed By: B. Acock and V. R. Reddy

Title: Integrated Pest Management Technologies for Sustainable Agriculture, Efficacy and Environmental Impact, and Comparisons with Conventional Systems

Objectives: 1) Develop long-term, multi-disciplinary studies of pest management in field crops under sustainable and conventional systems, including the role of cultural practices (row spacing, cover crops, crop rotation, mulches, waste utilization, etc.; 2) collect and analyze data from pest management systems on crops, weeds, insects, pathogens, soil tilth, water holding capacity, and pesticide movement in soil and groundwater; 3) develop an economic assessment of all practices mentioned above as they relate to crop production and pest management, and their effects on food quality; and 4) develop a data base for computer modelling capable of simulation and prediction of field events.

Rationale and Relation to Sustainable Agriculture: In order for farmers to abandon successful production systems presently used and adopt new sustainable agricultural systems, they must be convinced that the new systems are better than the old ones. Experiments with selected cropping systems in the same field area permit acquisition of scientific information as well as demonstration of systems performance.

Approach: 1) Locate a 10-20 acre field site at BARC suitable for establishing a long-term research project; 2) develop cooperative research protocols for studying a) conventional pest management systems and b) pest management in sustainable agriculture systems. Conventional systems include tillage and application of chemical pesticides for weed, insect, and disease control. Sustainable systems include tillage, crop rotations, minimum pesticide doses, biological and cultural pest control such as cover crops, mulches, row spacings, crop competition, and utilization of naturally derived pesticides and degradable waste materials; 3) utilize the services of the Biometrics Lab for the design of the field experiments and data analyses; 4) data to be collected will include pertinent information normally collected by field researchers including soil physical, chemical, and biological parameters, floral taxonomy, and groundwater characteristics before, during, and after the study; and 5) the Farm Management Branch will be expected to perform planting, harvesting, and other work as required. New equipment will be obtained as required.

Participants:

a) Weed Science Laboratory, PSI
   Ben Coffman
b) Biocontrol of Plant Diseases Laboratory, PSI
   Deborah R. Fravel
c) National Germplasm Resources Laboratory, PSI
   A. K. Stoner
d) Pesticide Degradation Laboratory, NRI
   G. F. Fries
e) Soil Microbial Systems Laboratory, NRY
   D. D. Kaufman
f) Environmental Chemistry Laboratory, NRI
   J. R. Plimmer
g) Farm Management Branch - Ft. Detrick Weed Science Lab

Additional Funding Use:
Additional research associates and technicians.

Proposal Prepared By: Ben Coffman

Title: Microbial Agents, Entomophagous Arthropods, and Behavior-modifying Chemicals to Control Insects, Reduce Pesticides in Foods, and Enhance Sustainable Agriculture

Objectives: Develop, evaluate, and implement biologically based methods of control for insects attacking vegetable crops that will contribute to the production of high quality, affordable vegetables without degrading the environment or depleting natural resources.

Rationale and Relation to Sustainable Agriculture: The ability to produce quality vegetables is being seriously impaired by the rapidly decreasing availability of efficacious insecticides. This decreasing availability is associated with (1) broad concern by the general public about pesticide residues in food; (2) suspected oncogenicity of insecticides; (3) pest resistance; and (4) lack of financial incentives for companies to assume costs of pesticide registration or re-registration. Therefore, there is a critical need to develop biologically based controls to protect vegetable crops. Since markets for many of the potential alternatives to pesticides are small, increased involvement of the public sector in their development and implementation will be required to make them available. Thus, a strengthened and coordinated research effort at BARC to serve the needs of the northeastern U.S. should be undertaken. The fundamental research underway at BARC on microbials, behavior-modifying chemicals, and hormones can provide a strong knowledge base to support an applied research program.

Approach: There is a critical need for more efficacious controls for insect pests such as the Colorado potato beetle, diamondback moth, tomato fruitworm, cabbage looper, whiteflies, aphids, leaf miners, and squash bugs. The principle crops involved include tomatoes, potatoes, melons/squash, cabbage, and lettuce. The control technologies to be developed and evaluated include (1) genetically improved strains of Bacillus thuringiensis and nuclear polyhedrosis viruses, (2) enhancement of predation and parasitism, including use of behavior-modifying chemicals, (3) importation of more effective parasites, and (4) natural plant products. The more promising control technologies will be combined with known cultural and physical controls to develop practical integrated pest management systems. Models will be developed to aid in transferring resulting technology to users.

Participants:

1) Insect Biocontrol Laboratory, PSI
   James L. Vaughn
2) Vegetable Laboratory, PSI
   William Cantelo
3) Fruit and Nursery Crops Laboratory, PSI
   J. Neal
4) Insect Chemical Ecology Laboratory, PSI
   Barbara Leonhardt

Additional Funding Use:
Additional five SYs needed

Proposal Developed By: Roger Ratcliffe

Title: Achieve the Full Potential of Integrated Control of Plant Diseases as a Major Component of Sustainable Agriculture

Objectives: 1) Develop integrated control of plant diseases with cultural practices, reduced amounts of pesticides and beneficial fungi; 2) determine the interactions of pesticides, fertilizers and cultural practices with biocontrol fungi; 3) select or produce new strains of biocontrol fungi compatible with reduced amounts of pesticides to promote integrated control.

Rationale and Relation to Sustainable Agriculture: Integrated control programs have significant potential to reduce pesticide use and thus reduce the possibility of food and water contamination. Integrated control also has the potential to reduce the total pesticide load and, hence, the residues introduced into soil/water environment. Reduction of pesticide use by the introduction of biocontrol fungi compatible with pesticides or with other practices will accomplish one of the most important goals of the sustainable agriculture program, namely, minimize the deleterious effects of agricultural chemicals on man, wildlife and the environment.

Approach: Integrated procedures which combine cultural practices or reduced amounts of pesticides with biocontrol fungi will be introduced. Research will also be done to determine the potential of integrated control through development of pesticide-resistant strains of biocontrol fungi by genetic manipulation. Specifically, research will be performed to: (i) Refine pesticide application technology to reduce the amount needed for disease control; (ii) use available fungal biotypes tolerant to pesticides or develop biotypes tolerant to pesticides by genetic manipulation that will combine the traits of effective biocontrol capabilities and decreased sensitivity to pesticides and use such biotypes in integrated control systems; (iii) expand current research on approaches to weaken soilborne fungal propagules by physical and chemical means (solarization, sublethal fumigation, etc) to make them more sensitive to biocontrol agents and perform studies in the field to assess the weakening phenomenon on pathogenesis; (iv) expand research on biocontrol formulations and delivery systems, especially those involving complex systems compatible with integrated control; (v) expand research to identify and characterize naturally-occurring biocontrol systems (suppressive soils) and from these isolate and identify microbes responsible for disease suppression; and (vi) perform studies in the field to test biocontrol systems by combining resistant biocontrol biotypes with reduced amounts of pesticides.

Participants:

a) Biocontrol of Plant Diseases Laboratory, PSI
George C. Papavizas
Deborah R. Fravel

b) Nematology Laboratory, PSI
Robin N. Huettel

c) Florist & Nursery Crops Laboratory, PSI
James C. Locke

Additional Funding Use:
Two new SY positions or two research associates.

Proposal Prepared By: George C. Papavizas

Title: Development of Microbial Gene Probes for Characterizing Beneficial Plant/Microbe /Soil Interactions in Sustainable Agriculture

Objectives: 1) Develop immunoassay systems with monoclonal antibodies for identification, tracking, and quantification of root and rhizosphere colonization by beneficial soil microorganisms; 2) increase effectiveness of VAM fungi and other associated beneficial rhizosphere microbes in improving the growth of plants in low-input farming systems by enhancing microbial competitiveness, colonization, compatibility, and pest control mechanisms; 3) determine the role plant exudates play as controlling factors in managing microbial populations and activities in the rhizosphere and assess the effect of introduced genetically engineered microorganisms on these processes.

Rationale and Relation to Sustainable Agriculture: A major challenge facing soil microbiology is whether microbial activities in the rhizosphere can be controlled to the advantage of the plant. The mechanisms and processes involved in plant-microbe and microbe-microbe interactions are poorly understood, but the accumulated information points strongly toward the involvement of material recognition and genetic control of specific biochemical determinants. Specific monoclonal antibodies would make universal standards available to researchers needing to identify specific isolates such as those to be evaluated at many locations. Availability of tools that can be used for proper assessment of the biology and ecology of beneficial soil microorganisms under field conditions will ultimately lead to an understanding of crop management conditions which maximize the benefits of indigenous or introduced microorganisms.

Approach: Develop immunoassay systems to identify soil microorganisms which benefit plant growth and determine factors affecting their growth in soil and plant rhizosphere. Analyze plant exudates using chromatography and relate to microbial populations and activities.

Participants:

a) Soil-Microbial Systems Laboratory, NRI
   Patricia Millner
   Jeffrey Buyer
   Lawrence Sikora
b) Biocontrol of Plant Diseases Laboratory, PSI
   G. C. Papavizas
   D. P. Roberts

Additional Funding Use:
Additional personnel to work with additional crops would be employed. Research Associates and technical support.

Proposal Developed By: D. D. Kaufman

Title: Enhance Agricultural Sustainability and Reduce Losses from Soilborne Plant Pathogens and Nematodes with Soil Management Practices

Objectives: Discover what beneficial microorganisms serve to hold soilborne plant pathogens and nematodes in check under natural conditions and how--by cropping systems and soil management--conditions can be produced in soil to enhance agricultural sustainability that will also favor microbial antagonists to the pathogens.

Rationale and Relation to Sustainable Agriculture: The proposed research involves studies of several alternative agricultural practices or systems components that will contribute to a sustainable agriculture. The proposed studies of the soil and crop management techniques will increase our knowledge of the beneficial biological factors that affect disease and nematode control. Acquiring such knowledge will enable us to (i) devise natural pest control systems in order to reduce the need for synthetic pesticides and (ii) understand what microbes are important in organic matter decomposition and plant nutrition in order to reduce the need for synthetic fertilizers.

Approach: Investigate natural interactions between plant pathogens and beneficial microorganisms in soil and plant rhizosphere. Research will be performed to understand the factors affecting natural antagonism, disease suppression and crop production sustainability. The shift in the microbial equilibrium that will enhance biocontrol, sustain plant productivity, and take the stress off the crops profitably will be attained by studying: (i) Use of organic amendments and green manures (e.g. cover crops, plant residues, composts); (ii) crop rotations, especially systems involving leguminous plants; (iii) cultural practices (e.g. irrigation, types of plowing, alterations of soil pH, sanitation, adjustment of the timing of planting and harvest to avoid peak periods of the pathogens, etc); (iv) monoculture (e.g., controls takeall of wheat after 5-6 years); (v) tillage practices (e.g. ecofallow, no tillage, minimum tillage); and (vi) sublethal chemical and physical treatments (e.g. plastic mulching, sublethal fumigation, etc). Attempts will also be made to understand the nature, dynamics, and mechanisms of disturbance of plant-associated microbial communities.

Participants:

1) Biocontrol of Plant Diseases Laboratory, PSI
   George C. Papavizas
   Robert D. Lumsden
2) Nematology Laboratory, PSI
   Robin Huettel
3) Soil Microbial Systems Laboratory, NRI
   Donald D. Kaufman

Additional Funding Use:
Three new SY positions or three new research associates.

Proposal Developed By: George C. Papavizas

Title: Low-Input Grazing Systems for Cattle and Sheep Production

Objective: To develop improved economic grazing systems for ruminants that exploit the following technologies: 1) Year-round or extended grazing that minimizes harvesting, storage and processing of forage, and 2) Use of cover-crops to optimize the utilization and/or conservation of nutrients, particularly nitrogen, in integrated crop-livestock production systems.

Rationale and Relation to Sustainable Agriculture: Ruminant production is a forage-based enterprise with forages making up approximately 70 to 90 percent of the total dry matter consumed within the life span of a ruminant animal. The most economical means of providing the ruminant with this forage is through grazing. Extended and/or year-round grazing is possible in the Mid-Atlantic region with appropriate pasture development that allows for stock-piling of forage in the field for later winter grazing. On a small scale, year-round grazing has been successful at Beltsville in cooperative studies conducted by the University of Maryland and the Ruminant Nutrition Laboratory. This needs to be extended to include sheep and dairy cattle where appropriate. The use of cover crops offers the advantage of reducing nutrient loss thereby increasing the availability of nutrients harvested as forage, animal products or subsequent grain crops. Agronomic research is currently underway cooperatively between scientists at the University of Maryland and Beltsville. We have an opportunity to utilize beef cattle, dairy cattle and sheep in designed experiments that would add ruminant production as a component of a cover-crop forage/crop production system. There is considerable interest in the northeastern U.S. regarding the application of pasture systems to both sheep and dairy cattle production and the use of cover-crop systems to support milk production. Both year-round grazing and use of cover crops reduce inputs of labor, energy and fertilization; however, the information needed to put such management systems into practice is lacking.

Approach: Research conducted at Beltsville, in cooperation with the University of Maryland, has successfully demonstrated year-round grazing for a beef cow/calf herd and has shown the effectiveness of cover crops in reducing the loss of nutrients via leaching. This proposal would extend the year-round grazing concepts to include sheep and non-lactating dairy cattle. These studies would be conducted in cooperation with the University of Maryland's Agronomy Department and utilize animals and pastures in defined grazing trials at Beltsville. The cover crop research incorporates the ruminant animal as a component in a cover-crop forage/crop system. It would initially include growing and lactating dairy cattle to measure animal production potential in defined grazing and digestion trials but could include beef cattle and sheep. Productivity and economics of the total system would be of primary interest in addition to the evaluation of cover-crop composition and nutrient quality.

Participants:

1) Nonruminant Nutrition Laboratory, LPSI
   Theron Rumsey
2) Meat Science Research Laboratory, PQDI
   Morse Solomon
3) University of Maryland, Agronomy Department
   Les Vough
   Jim Holderbaum

Additional Funding Use:

One full-time SY (ruminant nutritionist), facility costs, acquisition costs of animals and forage, equipment and research supplies.

Proposal Developed By: Theron Rumsey

Title: A Silage-based Low-input Feeding System for Poultry Production

Objective: To develop and evaluate non-conventional rations utilizing legumes and silage for growing and breeder chickens and turkeys.

Rationale and Relation to Sustainable Agriculture: Feed is the largest single cost in poultry production. A large portion of feed cost arises from the transportation and drying of feed grains, processing and mixing of the feed, and transportation of finished rations to the farms. Substantial savings are possible if poultry producers in areas of grain and forage production can use the feed directly, without drying, processing, or long-distance transportation. Substantial use of alfalfa in poultry rations would reduce reliance on conventional feed grains and reduce nitrogen use on cropland. Development of this system would encourage location of poultry production closer to crop-production areas, thereby reducing the intensity of poultry production and permitting better utilization of poultry waste on cropland, and may make poultry production profitable in regions of the country unsuited to feedgrain production but able to grow silage.

Approach: LISA research conducted at the University of Wisconsin has shown that turkey breeder hens can be reared to egg production on alfalfa pasture and then raised in confinement on a ration consisting of 53 percent high moisture corn, 21 percent alfalfa and 21 percent field peas. This ration is more palatable than conventional rations and turkeys maintain body weight and egg production equal to conventionally-fed hens with a 50 percent reduction in feed costs.

Areas to be investigated include: optimization of the composition and preparation of silage for feeding poultry, particularly for growing birds and breeder chickens; Supplementation with high-energy additives such as fat to supply the energy needs of rapidly-growing market birds; Determination of the physiological effects of feeding silage on growth, egg production, fertility and hatachability, carcass composition and meat flavor/quality; Analysis of the economic costs and benefits in various geographic areas; Field trials in several geographic areas to demonstrate the feasibility and advantages of such a feeding system to commercial poultry producers.

Participants:

1) Avian Physiology Laboratory, LPSI
   John A. Proudman
   Kim Maruyama
2) Ruminant Nutrition Laboratory, LPSI
   Barbara Glenn
3) Meat Science Research Laboratory, PQDI
   Morse Solomon
4) Systems Research Laboratory, NRI
   Yao-chi Lu
5) University of Wisconsin, Department of Poultry Science
   Bernard C. Wentworth
   WieDong Wu

Additional Funding Use:

Technical support, animal caretaker, graduate student
Minor renovation of Bldg. 255A, construction of silo
Supplies, minor equipment, facility costs, statistical services
Animal and feed costs, travel for field trials

Proposal Developed By: John A. Proudman

Title: Improve Artificial Insemination Technology for Increased Efficiency in Turkey Breeding

Objective: To develop procedures applicable to the turkey industry for the preservation of turkey semen to 48 hours.

Rationale and Relation to Sustainable Agriculture: Improvement sin the management of the male turkey breeder coupled with advances in AI technology, specifically the development of procedures to store semen for 48 hours, has the potential to develop a new market (sale of semen) within the turkey industry. This, in turn, may result in a reduction of the total number of male breeders maintained on commercial farms throughout the U.S. On individual farms, more intensive use of the male turkey (decreasing the male-to-female ratio) will lead to both an increase in efficiency of production and improve the quality of the final product through increased selection pressure for desirable traits.

Approach: All commercial turkey breeders use artificial insemination for the production of fertile eggs. Work performed in the Avian Physiology Laboratory (LPSI) and elsewhere have advanced artificial insemination (AI) technology to a stage where turkey semen can be collected from turkey breeder males, diluted with a solution (diluent), and stored at 5 to 10^{o}C for up to 8 hours without a decline in fertility. As a result of this advance in technology, several commercial turkey breeders have adopted a novel management scheme for their male breeders-the central male farm. This development, which involves for the first time the complete separation of the male and female breeders, has several advantages over maintaining both sexes on the same farms. These advantages include a reduction in the number of males necessary to maintain the breeder program and an improvement in management of breeder males with resultant improved fertility. Finally, because fewer males are necessary there is an acceleration in the genetic selection for desirable traits. The proposed research would focus on increasing the shelf-life of semen for commercial use to 48 hours. The capacity to simply dilute turkey semen and store at a cold temperature (as opposed to freezing the semen, which results in unsatisfactory levels of fertility) would have a direct effect on the breeder sector of the turkey industry by creating a market for the sale of high quality semen to breeders throughout the U.S. and world-wide. Further improvements in AI technology could also lead to a reduction in the number of sperm cells actually required per insemination does and to a decrease in the number of inseminations per hen over a 22 week egg-production period.

Participants:

1) Avian Physiology Laboratory, LPSI
   Murray R. Bakst
2) Nonruminant Animal Nutrition Laboratory, LPSI
   Mark Richards
3) North Carolina State University, Poultry Science Department
   Vern Christensen
4) Pennsylvania State University, Poultry Science Department
   Guy Barbato

Additional Funding Use:
Technical support, supplies, animal costs

Proposal Developed By: Murray R. Bakst

Title: Genetic Enhancement of Disease Resistance to Enteric Pathogens in Poultry

Objectives: To improve natural immunity of poultry by genetic selection.

Rationale and Relation to Sustainable Agriculture: Abundant information is available in mammalian systems that suggests a role of host genes in controlling disease resistance. The identity of host genetic factors controlling disease resistance in poultry needs to be defined so that this information can be incorporated into poultry breeding programs. The goal of such programs would be to improve natural resistance to poultry diseases, thereby reducing both the mortality due to infection and the use of preventive and therapeutic drugs.

Approach: Current research is investigating the role of host genes in disease susceptibility to enteric pathogens, including salmonellosis and coccidiosis. Genetic markers appear to be available that will permit identification of individuals with enhanced natural immunity. We propose to incorporate information from genetic screening into a breeding program to produce chicken lines with enhanced disease resistance to salmonellosis and coccidiosis.

Participants:

1) Protozoan Diseases Laboratory, LPSI
   H. Lillehoj
2) Regional Poultry Research Laboratory, East Lansing, MI
   Larry D. Bacon
3) Poultry Meat Quality and Safety Research, Athens, GA
   Norman J. Stern

Additional Funding Use:

Research Associate and technical support/animal caretaker
Laboratory supplies and minor equipment

Proposal Prepared By: H. Lillehoj

Title: Use of Bovine Colostrum to Prevent and Treat Disease in Companion Animals, Livestock and Humans Infected with Protozoan Parasites

Objective: Utilize the colostrum from dairy cows, which is now discarded for lack of usefulness, for prevention and treatment of the widespread diarrheal disease, cryptosporidiosis, for which there are no known effective drugs. Apply this concept to other diseases involving intestinal protozoa such as bovine, ovine and porcine coccidiosis.

Rationale and Relation to Sustainable Agriculture: Use of colostrum will increase efficiency and reduce postharvest losses, both with regard to use of the milk itself as well as protecting the health of the young animals.

Approach: It has been shown that cows immunized by intramammary infusion of Cryptosporidium produce hyperimmune colostrum that can protect calves, experimentally infected mice, as well as naturally infected humans. The active agents in the colostrum have been shown to be specific immunoglobulins. Through collaborative efforts with dairy scientists the hyperimmune colostrum should be prepared in a form that has a long shelf life and requires a minimum amount of processing while maintaining its antiparasite activity. Freeze-drying of skimmed milk or whey made from colostrum would be two such preparations that should be tested in animal models.

If new resources were combined with current resources a genetic engineering effort and testing program could be mounted to clone the parasite genes that express the protein that stimulates the bovine immune response in the mammary gland. The ability to administer such a "vaccine" is necessary to commercialize this process because it is unfeasible to distribute frozen parasite preparations, such as those now used in the laboratory, to farmers or veterinarians for hyperimmunizing cows to produce the colostrum with the desired activity.

Upon successful completion of the immunization/treatment program for cryptosporidosis, programs could be similarly patterned for other protozoan diseases that cause diarrhea in companion animals, livestock, and humans.

Participants:

1) Zoonotic Diseases Laboratory, LPSI
   Ronald Fayer
2) Protozoan Diseases Laboratory, LPSI
   Harry D. Danforth
   Mark C. Jenkins
3) Milk Secretion and Mastitis Laboratory, LPSI
   Albert J. Guidry
4) Auburn University, College of Veterinary Medicine
   Byron L. Blagburn
5) John Hopkins University School of Medicine, Division of Infectious Diseases and Gastronenterology
   Cynthia Weikel
6) Kansas State University, Division of Biology
   Michael Tilley

Additional Funding Use:
Research Associate and technical support
Supplies and equipment

Proposal Developed By: Ronald Fayer

Title: Immunology and Identification of Genes and Gene Products Controlling Resistance to Helminths of Ruminants

Objective: To improve the production efficiency of ruminant food animals through the reduction of helminth parasite burdens by natural mechanisms.

Rationale and Relation to Sustainable Agriculture: Project will improve the productive efficiency of food animals while reducing the frequency of antihelmintic drug application. This reduction in drug usage will: 1) reduce producer costs; 2) diminish the selective pressures on parasite populations which lead to drug-resistant strains; 3) reduce drug residues in the food supply; and 4) reduce environmental contamination with the newer antihelmintics which possess potent activities against arthropod species.

Approach: As currently funded, the CRIS (1265-31340-004-00D) attempts to identify and characterize major histocompatibility types in ruminant livestock that affect resistance/susceptibility to gastrointestinal helminth parasites; to characterize the mechanisms of immune function in resistance or tolerance to gastrointestinal helminthic infection; and to elucidate the role of host hormonal regulation of immunity to helminthic infections. Project will produce reagents that will accurately and reliably identify the class I and class II cell surface antigens of the bovine major histocompatibility complex (BoLA) and associate the genetic basis of these expression products with resistance or susceptibility to infectious agents. Non-BoLA genes controlling resistance will be identified in BoLA homozygous cattle which have been selected for high and low levels of resistance. Additional personnel and funding are needed to: 1) address studies on the development of DNA probes to identify (speciate) parasite eggs; 2) clone recombinant cytokines for resistance studies; and 3) conduct the labor intensive and costly analysis of parasite/host models that utilize cattle.

Participants:

1) Helminthic Diseases Laboratory, LPSI
   Louis C. Gasbarre
2) Subtropical Agricultural Research, Brooksville, FL
   Andrew C. Hammond
3) University of Maryland-WREC, Queenstown, MD
   R. Brinsfield
4) University of Maryland-Eastern Shore, Princess Anne, MD
   T. Mollet

Additional Funding Use:

Postdoctoral Scientist (Molecular Biology), technical support, equipment, animal maintenance costs

Proposal Developed By: Louis C. Gasbarre

Title: Production of Bispecific Antibodies to Combat Mastitis Pathogens in Lieu of Antibiotics

Objectives: To produce bispecific antibodies that would eliminate bacteria in vivo by redirecting cytoxic immune cells (neutrophils).

Rationale and Relation to Sustainable Agriculture: Enhancing the effectiveness of endogenous cytotoxic immune cells to combat mastitis pathogens would reduce losses due to mastitis infection and reduce reliance on antibiotic treatment.

Approach: Cytotoxic cells have receptors to bind target cells and lyse them. Normal antibodies are targeting agents, binding to epitopes on target cells via their variable regions and serving as recognition sites for immune effectors such as Fc and complement receptors on cytotoxic cells such as neutrophils. Bispecific antibodies are created by chemical crosslinking or by fusing hybridoma cells. They bind to target cells (e.g., bacteria) by one variable region and to triggering molecules such as FcR for immunoglobulins on cytotoxic cells via their Fc region. The linkage of triggering structures to target cells induces target cell lysis which gives important clues to the signals used to elicit the immune process. Monoclonal antibodies to mastitis causing pathogens are available in the lab, and monoclonal antibodies to bovine FcR will be produced. Bispecific antibodies will be produced by chemical crosslinking of these monoclonals. The ability of the antibodies to result in targeted cell lysis will be monitored. Targeting studies will be used to determine which FcR are cytotoxic trigger molecules on bovine PMN. In vivo serum IgG binds to the FcR and modulates the interaction between receptor bearing cells and antibody-coated target cells. Therefore, more efficient approaches to mediate FcR function will be investigated. Using monoclonal antibodies against FcR, bispecific antibodies will be used to redirect cytotoxic PMN to kill bacteria and other targets without antibody blockade by the natural ligand. There have been results to indicate that although serum levels of IgG blocked classical ADCC, targeted lysis was not inhibited. Therefore, targeted lysis may be more effective than classical ADCC in vivo.

Participants:

1) Milk Secretion and Mastitis Laboratory, LPSI
   M. J. Paape
   Albert J. Guidry
2) Helminthic Diseases Laboratory, LPSI
   Joan Lunney
3) National Institutes of Health
   David Segal

Additional Funding Use:

Two new SY's (molecular biologist, immunologist/microbiologist)
Postdoctoral scientist, technical support, equipment, supplies

Proposal Developed By: M. J. Paape

Title: Efficacy of Bovine Somatotropin for Increasing Sustainability of Milk Production

Objectives: To demonstrate to farmers and the public the value of bovine somatotropin in enhancing the efficient production of milk while reducing adverse impacts of animal agriculture on land use and the environment.

Rationale and Relation to Sustainable Agriculture: A number of environmental pollution factors could be reduced by using fewer cows to produce the same amount of milk. It takes a certain amount of feed with a related amount of manure production to maintain the body weight of each cow. The savings would come about from the reduction in body weight maintenance requirements with fewer cows. This would mean less land would be needed to grow food for the cows with a concomitant reduction in fertilizer, herbacides and insecticides that are placed onto the land followed by a reduction in water pollution, etc. Fewer cows would also mean a reduction in manure pollution. If the reduction in pollution were significant, that information could help to convince the farmers and public of the advantages of bovine somatotropin.

Approach: Use of bovine somatotropin could maintain the level of our nation's milk production with fewer cows. A demonstration project is needed to compare convention and BST milk production systems to measure the reduction in land required for food production and the resulting decreases in environmental pollution factors (manure production; fertilizer, herbicide and insecticide use) resulting from increased milk production efficiency. This would require two large groups of cattle and the land required to house and feed them. Literature searches could also be made of existing relative data and estimates of the savings made from that.

Participants:

1) Milk Secretion and Mastitis Laboratory, LPSI
   John E. Keyes
   Robert H. Miller

Additional Funding Use:

Acquisition and maintenance of animals, technical support, supplies

Proposal Developed By: John E. Keyes